[Translation]

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COMMISIONER

[ABSTRACT OF THE DISCLOSURE]

[ABSTRACT]

The present invention relates to a method for setting initial error value of a rate-matching algorithm in a Wideband Code Division Multiple Access (WCDMA) Hybrid ARQ system, and more particularly, to a method for setting a rate-matching algorithm suitable for Hybrid ARQ type II systems with full retransmission.

The present invention disclose a method of setting initial error value of the rate-matching algorithm, in which the initial error value of the rate-matching algorithm is varied upon the number of the retransmission of the bits, the initial error value of the rate-matching algorithm is varied in such a manner that a modular operator calculated from a function with which the number of the retransmission is a variable is combined with the initial value, the initial error value of the rate-matching algorithm of the hybrid ARQ system is varied by a function which is to be simply increased depending upon the number of retransmission varied, or setting the initial error by using the bit reversing, and the initial value is varied by a function having the number of the retransmission of bits as a variable, is also applied to a coding diversity.

[TYPICAL DRAWING]

FIG. 2

[INDEX WORDS]

CDMA, ARQ

[SPECIFICATION]

[TITLE OF THE INVENTION]

RATE MATCHING ALGORITHM FOR HYBRID AUTOMATIC REPEAT REQUEST(ARQ) SYSTEM

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 illustrates a graphical presentation showing how the rate-matching algorithm is invoked in a hybrid ARQ type II system in accordance with the present invention; and

FIG. 2 is a flowchart illustrating a method of setting an initial error value of a rate-matching algorithm for a hybrid ARQ type II system in accordance with the present invention.

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND DISCUSSION OF THE RELATED ART]

The present invention relates to a method for setting initial error value of a rate-matching algorithm in a Wideband Code Division Multiple Access (WCDMA) Hybrid ARQ system, and more particularly, to a method for setting a rate-matching algorithm suitable for Hybrid ARQ type II systems with full retransmission.

More particularly, the present invention relates to the method for setting initial error value of rate-matching algorithm in the WCDMA Hybrid ARQ system, which is realizing Hybrid ARQ type II system by varying the initial error value of the rate-matching algorithm in accordance with a number of retransmission satisfying conditions in that the bits which are being coded and punctured by the rate-matching, for acquiring the optimal condition in the hybrid ARQ system, are included in a retransmitting packet that is retransmitted before than predetermined bits those being previously retransmitted

without being punctured, and the data bits transmitted many times should be transmitted subsequent to the data bits transmitted a less number of times to be more advantageous in performance than the retransmission of the bits those being repeatedly re-transmitted bits during the repetition of the rate-matching algorithm.

An object of the hybrid ARQ system, in which an automatic repeat request (ARQ) and forward error correction (FEC) techniques are combined, the ARQ technique allowing a receiving system makes requests to re-transmit data if the data were received erroneously and the FEC technique preventing a degradation of channels, is to increase a reliability of the communication system and enhancing the performance.

The coding rate of the channel code in an adaptive hybrid ARQ system starts from a source-coding rate, and it decreases as the number of retransmission increases in order to increase reliability of the data transmission. Such hybrid ARQ technique being adaptive to channel environments is essential to a system that provides a multimedia service.

The adaptive ARQ technique bases on an adaptive error correction technique: the number of the surplus data bits gradually increases during the retransmission process in order to protect the data bits from being degraded. In addition, the adaptive ARQ technique uses one of "stop and wait", "go back N", and "selective repeat" protocol method, and a data packet having a length L includes n information bits, np parity bits and '0' tail bits in m numbers.

In this instance, the data packet is expressed as c0 and the source coding rate of an encoder is expressed as 1/h. The encoded bits are periodically punctured in accordance with an optimal puncturing pattern, and thus rate compatible punctured codes (RCP) are obtained. If the coding rate of the RCP codes are referred to as Rk, it satisfies the expression that $k \geq 1$ and $Rk > Rk + 1$. An incremental code which can be

expressed as Ck is not included in a word encoded with a higher coding rate but has the code bits included in a word with an Rk coding rate. The incremental code is interleaved to be transmitted through the channels.

A typical hybrid ARQ system starts to transmit the data encoded with a reasonably high coding rate (e.g., R1=1), and in a mobile station the received data signal is encoded and the mobile station requests to resend the data (sends NAK) if they were received erroneously.

Then, the transmitting system, which receives NAK, sends an incremental code word encoded with a lower coding rate. Despite of a support of the source coding rate of the encoder, if the transmitting system fails to transmit the signals without errors, it can retransmit the signals from the first stage. In other words, if the data with which the encoder has 1/h coding rate is failed from transmission, it can be transmitted from the first stage, only that the encoding rate should be lower than 1/h.

In general, the hybrid ARQ system often uses any one of convolutional or turbo encoding techniques for encoding a code, and the hybrid ARQ system can be classified into a type II or type III system based on whether the encoded code is a Rate Compatible Punctured (RCP) code or a Complementary Punctured (CP) code. In addition, the system is classified into type I system for re-transmitting the same signal.

The current Third Generation Partner Project (3 GPP) meetings for WCDMA standards sets the hybrid ARQ type 1 system as 'Working assumption' of 'Release 2000', and continues to discuss about the hybrid ARQ type II or type III system. As mentioned above, the hybrid ARQ system is a combined system of the ARQ technique and the FEC technique, which can be divided in four different types: (1) Hybrid ARQ type I system without code combining, (2) Hybrid ARQ type I system with code combining, (3) Hybrid ARQ type II system with full retransmission, and (4) Hybrid

ARQ type II system with partial retransmission.

(1) Hybrid ARQ Type I System without Code Combining

In this system, a transmitter adds a CRC code to a data packet and performs an error correction coding process before sending the packet. Then, a receiver performs a CRC inspection and requests to retransmit if any error exists. Thereafter, the transmitter resends a same packet, and the receiver decodes the retransmitted packet independently. This system is set as "Working assumption" in current 3GPP standards.

(2) Hybrid ARQ Type I System with Code Combining

This system is similar to the Hybrid ARQ type I system shown above except that the receiver initially combines the originally transmitted packet with the retransmitted packet, and it decodes the combined packet. It requires an additional memory space, and the number of data bits representing a soft symbol for combining must be considered.

(3) Hybrid ARQ Type II System with Full Retransmission

In this system, a supplementary coding increase rate for the originally transmitted packet is retransmitted. Aforementioned supplementary redundancy is referred to as an incremental redundancy. In this system, the data capacity of the incremental redundancy which is fully retransmitted should be the same as the originally transmitted packet that being yet combined with. In this case, the respective retransmitted packets can be separately decoded.

(4) Hybrid ARQ Type II System with Partial Retransmission

This system is identical to the Hybrid ARQ type II system in method 3) with full retransmission except that the re-transmitted incremental redundancy is smaller in size than that of the of the original transmission packets, and the retransmitted packet cannot be decoded separately.

As mentioned above, there are four different types of hybrid ARQ systems. The

current Third Generation Partner Project (3 GPP) meetings for WCDMA standards are only trying to decide what type of ARQ system should be used. On the other hand, there is no discussion held regarding the matter that how the substantial algorithm should be structured in case of applying the hybrid ARQ system thereto.

Therefore, it is crucially important to provide the specific algorithms for hybrid ARQ systems. In addition, in order to achieve the optimal result, various techniques and modification should be applied to such algorithms.

The existing rate-matching pattern generating algorithm can be briefly described as follows:

In the above algorithm, x_{i1}, x_{i2}, x_{i3}, . . . and x_{iX_i} represent the number of the transport channels (TrCH) to be used, where i represents the number of retransmission.

Also, parameters of X_i, e_{ini}, e_{plus} and e_{minus} are given as;

if puncturing is to be performed

$e = e_{ini}$

$m = 1$

do while $m \leq X_i$

$e = e - e_{minus}$

if $e < 0$, then

set bit $x_{i,m}$ to δ (Herein, δ is defined as a number value other than 0 or 1)

end if

$m = m + 1$

end do

else

$e = e_{ini}$

$m = 1$

do while $m \leq X_i$

$e = e - e_{minus}$

do while $e \leq 0$

repeat bit $x_{i,m}$

$e = e + e_{plus}$

end do

$m = m + 1$

end do

end if

The above architecture explains that, in the present algorithm, the e is initially given, which can be expressed as $e = e_{ini}$, if the m representing the index of a current data bit is set to 1, and if m is not greater than X_i, it can be defined that $e = e - e_{minus}$.

If the $e \leq 0$, the bit $x_{i,m}$ can be set as integer δ by inspecting whether it is punctured (only that the integer should be a numeral value other than 0 or 1 in order to show the position the integer δ is punctured), and thereafter an error is reset by $e = e + e_{plus}$.

After completion of the process, the next bit is defined by $m = m + 1$, and the rest of the bits are set as initial error value determined by $e = e_{ini}$. The m representing the index of the current data bit is set to 1, and if $m \leq X_i$, it satisfies that $e = e - e_{minus}$, and the repetitiveness of the data transmission is inspected by $e \leq 0$ to repeat the bit and subsequently executing $e = e + e_{plus}$. The repeated bits are attached at the rear section of an original block.

[TECHNICAL TASKS TO BE ACHIEVED BY THE INVENTION]

Accordingly, the present invention is directed to a method of setting an initial

error value of a rate-matching algorithm that substantially obviates one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method of setting an initial error value for a rate-matching algorithm of a hybrid ARQ system.

Another object of the present invention is to provide a method of setting an initial error value for determining the structure of re-transmitting bits using a rate-matching algorithm in Hybrid ARQ type II with full retransmission.

Still another object of the present invention is to provide a method of setting an initial error value for a rate-matching algorithm of a hybrid ARQ system, which shows an optimal performance in operating the hybrid ARQ system by varying the initial error value depending on the number of retransmissions.

Still another object of the present invention is to provide a method of setting an initial error value for a rate-matching algorithm of a hybrid ARQ system, in which a modular operator calculated from a function with which the number of the retransmission is a variable is combined with the initial value.

Still another object of the present invention is to provide a method of providing a method of setting an initial error value for a rate-matching algorithm to which Hybrid type II ARQ system can be applied so as to enable the optimal performance of the ARQ system without affecting an existing multiplexing system, by setting the initial error value of the rate-matching algorithm of the hybrid ARQ system to be simply increased depending upon the number of retransmission varied, or setting the initial error by using the bit reversing.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from

practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[PREFERRED EMBODIMENTS OF THE INVENTION]

The current Third Generation Partner Project (3 GPP) meetings for WCDMA standards are only trying to decide what type of ARQ system should be used. On the other hand, there is no discussion held regarding the matter that how the substantial algorithm should be structured in case of applying the hybrid ARQ system thereto.

Therefore, it is crucially important to provide the specific algorithms for hybrid ARQ systems. In addition, in order to achieve the optimal result, various techniques and modification should be applied to such algorithms.

One of the crucially important facts of achieving the maximum result for a Hybrid ARQ type II system with full retransmission is that the data bits punctured by coding and rate-matching must be transmitted prior to the data bits which were not punctured and transmitted previously. In addition to that, the data bits transmitted many times should be transmitted subsequent to the data bits transmitted a less number of times.

Therefore, using the method of setting the initial error value of the rate-matching algorithm to which the Hybrid ARQ type II is applied in accordance with the present invention, the initial value of the rate-matching algorithm for the re-transmitted bits is varied, so as to give priorities to the data bits transmitted fewer times. The rate-matching algorithm invoked in a hybrid ARQ system birth an assumption that the size of the packet being retransmitted is identical to the size of the packet previously transmitted, which can be embodied as FIG. 1.

FIG. 1 illustrates a graphical presentation showing how the rate-matching

algorithm is invoked in a hybrid ARQ type II system in accordance with the present invention.

As shown in FIG. 1, a rate-matching algorithm 102 is subsequent to a first transport multiplexing chain 101, which is again succeeded again to a second transport multiplexing chain 103, in which the system selects other initial values depending on the number of the retransmission of the bits. ,

In the rate-matching algorithm system in accordance with the present invention, the initial error value can be varied by following manners.

First, the method of setting initial error value of the rate-matching algorithm, in which the initial error value of the rate-matching algorithm is varied upon the number of the retransmission of the bits.

Second, the method of setting initial error value of the rate-matching algorithm, in which the initial error value of the rate-matching algorithm is varied in such a manner that a modul ar operator calculated from a function with which the number of the retransmission is a variable is combined with the initial value.

Third, the method of setting initial error value of the rate-matching algorithm, in which the initial error value of the rate-matching algorithm of the hybrid ARQ system is varied by a function which is to be simply increased depending upon the number of retransmission varied, or setting the initial error by using the bit reversing.

Fourth, the method of setting initial error value of the rate-matching algorithm, in which the initial value is varied by a function having the number of the retransmission as a variable, is applied to not only for hybrid ARQ type uplink but also hybrid ARQ type downlink.

Fifth, the method of setting initial error value of the rate-matching algorithm, in which the initial value is varied by a function having the number of the retransmission

of bits as a variable, is also applied to a coding diversity.

FIG. 2 is a flowchart illustrating a method of setting an initial error value of a rate-matching algorithm for a hybrid ARQ type II system in accordance with the present invention.

In the flow chart shown in FIG. 2, i represents a number of retransmissions.

First of all, at the step 201, a modular operator K which is for setting the initial error value of the rate-matching algorithm in accordance with the number of retransmission of bits is defined.

The modular operator K is obtained by

$K \leq e_{plus} / e_{minus}$

where e_{plus} and e_{minus} are originally given, and integer K is defined by

integer K = N(K) or N(K)+1,

where N(K) represents the maximum of a set of integer numbers being no more than e_{plus} / e_{minus}, if the value e_{plus} / e_{minus} is less than 1.

Next, the algorithm checks whether it is a "puncturing" mode or "repeat" mode (S202). If it is a "puncturing" mode, the algorithm sets the incremental value $e_{HARQ}(i)$ to i so as to give a variation to the initial value (S203). Similarly, if it is a "repeat" mode, the algorithm sets $e_{HARQ}(i)$ to i (S203). Finally, the new initial error value is determined by $e_{ini} = e_{ini} + (e_{HARQ}(i) \bmod K) \cdot e_{minus}$ (S204). In this instance, i set to 0 represents the first transmission, and i set to 1 represents the second transmission.

Alternatively, at the above step (S204), the e_{HARQ} (i) can be set as the following function to make the system more optimized.

In other words, the incremental value e_{HARQ} (i) can be set as

$e_{HARQ}(i)=PBR_{i\%K}$, where PBRi%K represents a list of numbers obtained by excluding any number greater than or equal to K from $BR_{j,n}$. Herein, $BR_{j,n}$ represents the

values obtained by bit-reversing j with n, where n represents an integer number that $2^{n-1}<K\leq 2^n$.

As an example of a bit-reversing, in case that $BR_{0,3}=0$, i.e., '0'= '000', the reversed code of the above code number from LSB to MSB will be still '000', which makes the $BR_{0,3} = 0$. And in case that $BR_{1,3} = 4$, i.e., '1' = '001', the reversed code of the above code number from LSB to MSB will be '100' that is to be '4' in decimal number. Thus, the $BR_{1,3}$ becomes 4.

For example, let's assume K=6 and n=3. Then $BR_{0,n}$=0(000->000), $BR_{1,n}$=4(001->100), $BR_{2,n}$=2(010->010) $BR_{3,n}$=6(011->101), $BR_{4,n}$=1(100->001), $BR_{5,n}$=5(101->101) $BR_{6,n}$=3(110->4011), $BR_{7,n}$=7(111->111), and PBR_0=0, PBR_1=4, PBR_2=2, PBR_3=1, PBR_4=5, PBR_5=3.

The method of setting an initial error value for the algorithm generating a rate-matching pattern can be applied to not only a downward link but also to an upward link. When the Transmission Time Interval (TTI) is set to a value greater than 1 for an upward link, an initial error value is set for each frame. Then the method described above can be used for setting the initial error value for each frame.

In addition, since the method of setting an initial error value in accordance with the present invention bases on code combining, it can be further applied to any other application that uses the code combining. Coding diversity is a method of maximizing the performance by employing a method that a plurality of base stations using different coding methods are code-combining with a handover terminal to be communicated with.

[EFFECT OF THE INVENTION]

In conclusion, in the method of setting an initial error value in accordance with the present invention, the initial error value depends on the number of transmissions made. Therefore, the maximum result can be obtained for the Hybrid ARQ type II

system with full retransmission.

It will be apparent to those skilled in the art than various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method of setting an initial error value of a rate-matching algorithm in a hybrid ARQ system, wherein the initial error value of the rate-matching algorithm is varied upon the number of the retransmission of the bits.

2. The method as claimed in claim 1, wherein the initial error value of the rate-matching algorithm is varied in such a manner that a modular operator calculated from a function having the number of the retransmission is set as a variable is combined with the initial value.

3. The method as claimed in claim 1, wherein the initial error value of the rate-matching algorithm of the hybrid ARQ system is varied by a function which is to be simply increased depending upon the number of retransmission varied, or setting the initial error by using the bit reversing.

4. The method as claimed in claim 1, wherein method of setting the initial value varied by a function having the number of the retransmission as a variable is applied to not only for hybrid ARQ type uplink but also hybrid ARQ type downlink.

5. A method of setting an initial error value of a rate-matching algorithm in a hybrid ARQ system, the initial error value being varied upon the number of retransmission of bits, the method comprising the steps of:

(a) calculating a modular operator K;

(b) checking whether it is a "puncturing" mode or "repeat" mode;

(c) calculating an incremental error value for adjusting the initial value depending on the number of retransmissions made; and

(d) calculating a new initial error value by adding said incremental error value with said original initial error value.

6. The method as claimed in claim 5, wherein the modular operator K is obtained by $K \leq e_{plus} / e_{minus}$, where e_{plus} and e_{minus} are originally given, and integer K is defined by integer K = N(K) or N(K)+1, where N(K) represents the maximum of a set of integer numbers being no more than e_{plus} / e_{minus}, if the value e_{plus} / e_{minus} is less than 1, and if it is a "puncturing" mode, the algorithm sets the incremental value $e_{HARQ}(i)$ to i so as to give a variation to the initial value, and subsequently the new initial error value is determined by $e_{ini} = e_{ini} + (e_{HARQ}(i) \bmod K) \cdot e_{minus}$ (S204).

7. The method as claimed in claim 6, wherein the incremental value $e_{HARQ}(i)$ can be set as $e_{HARQ}(i)=PBR_{i\%K}$, where PBRi%K represents a list of numbers obtained by excluding any number greater than or equal to K from $BR_{j,n}$.

DRAWINGS

FIG. 1

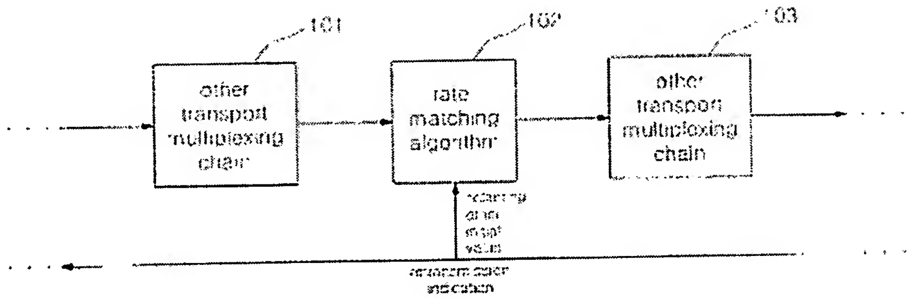

FIG. 2